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Technical Paper 294

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THE ASSIGNMENT MODULE: AN ELEMENT OF AN EXPERIMENTAL COMPUTER-ENHANCED CAREER COUNSELING SYSTEM FOR ARMY OFFICERS

Robert F. Eastman

CAREER DEVELOPMENT & SOLDIER PRODUCTIVITY TECHNICAL AREA

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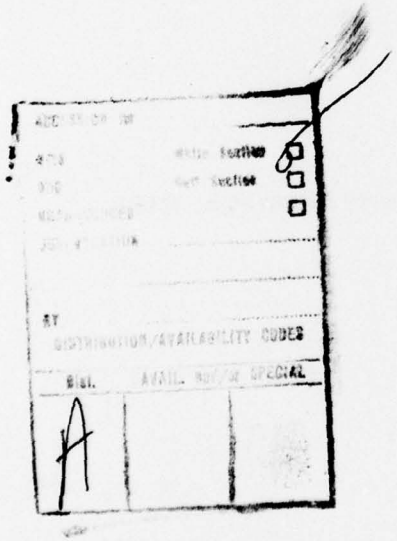

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An experimental, computer-enhanced career counseling system has been designed to study systematic approaches to the career counseling and assignment of Army officers. Within the assignment module, a policy-capturing program calculates sets of utility scores for personnel. The scores reflect suitability for assignment within a set of job categories. All officers are given a list of job assignments for which they are qualified. Officers can then express preferences for job categories from the list of possible

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assignments. Final assignments to job categories are made by using three personnel assignment algorithms representing varying degrees of optimality.

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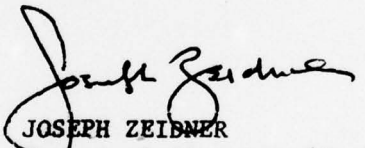
FOREWORD

The Career Development & Soldier Productivity Technical Area of the Army Research Institute for the Behavioral and Social Sciences (ARI) conducts research on Army officer and enlisted career progression systems, the role of women in the Army, and occupational qualifications and measurement. Part of the technology base research on career progression, in support of the Officer Personnel Management System (OPMS), has been the design of an experimental computer-aided career counseling system.

The present Technical Paper reports on the feasibility of a computer-aided assignment system using the Infantry Branch as a prototype. Other related reports include ARI Research Memorandum 77-2, which describes the assignment algorithm used, and Research Memorandum 77-3, which explains the algorithm's successful application to the Quartermaster Branch. Field experiments also have shown that a computer-aided career information system is acceptable to samples of officer users for whom the system is intended. Continuing investigations focus on cost-benefit analyses of this system. Work is done under Army Project 2Q762717A766, Manpower Systems Management (FY 78); Task C, Career Progression Systems.



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THE ASSIGNMENT MODULE: AN ELEMENT OF AN EXPERIMENTAL COMPUTER-ENHANCED CAREER COUNSELING SYSTEM FOR ARMY OFFICERS

BRIEF

Requirement:

As part of the program to improve the Army system of career counseling and assignment for officers, this project tested the technical feasibility of (1) using a computer-assisted system to assign officers and (2) quantifying the assignment policies and practices of a career branch.

Procedure:

Quantifiable aspects of assignment policies and practices in the Infantry Branch were reproduced in a program that derived job utility scores, which reflect suitability for particular types of assignments, from background variables in officers' records. Three computer-assisted assignment methods used the job utility scores to simulate assignment of 160 Infantry captains. The assignments made using these three methods were evaluated by comparing results with both actual assignments and suitable alternate assignments recommended by experienced branch personnel.

Findings:

The three computerized methods agreed well (80-86%) with both the actual assignments and the alternate assignments judged suitable by branch personnel.

Using average utility scores as a measure of success in matching officers and jobs, the three computerized methods achieved a significantly better fit of officers to job categories than did the manual assignment method.

Where the computerized methods were not acceptable to branch personnel, the two principal causes were (1) inadequacy of input data from the officers' records and (2) overweighting in the computerized methods of the importance of officers' preferences.

Utilization of Findings:

A computer-assisted assignment system that satisfies criteria used by officer career branches is feasible.

Such a system has the following advantages: (1) speedier assignments to job categories, (2) simultaneous consideration of a large number of officers and available positions, (3) greater objectivity and equity for officers, (4) more available time for special cases, (5) assurance that relevant variables are not overlooked, and (6) greater efficiency in file handling from using computerized files instead of personnel folders.

Individual officers could be certain that their preferences had an objectively consistent influence on final decisions about assignments. The speed and efficiency of a computer-assisted system would let officers know their probable assignments with enough lead time to revise preferences before final assignment.

THE ASSIGNMENT MODULE: AN ELEMENT OF AN EXPERIMENTAL COMPUTER-ENHANCED CAREER COUNSELING SYSTEM FOR ARMY OFFICERS

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THE ASSIGNMENT MODULE: AN ELEMENT OF AN EXPERIMENTAL COMPUTER-ENHANCED CAREER COUNSELING SYSTEM FOR ARMY OFFICERS

INTRODUCTION

Several studies have shown the need to improve career guidance given to Army officers, particularly junior officers (Franklin et al., 1968; U.S. Army War College, 1971; OERS Study Group, 1969). The diversity of career options, lack of a readily accessible central source of up-to-date career information, rapid changes in career information, seeming disregard of officer assignment preferences, and absence of a systematic approach to counseling and assignment have contributed to costs in valuable manpower resources and motivation loss that are unacceptable to today's military service.

An experimental computerized research facility was created at the Army Research Institute to conduct experiments in these career counseling problem areas. Preliminary research (Macpherson et al., 1978) indicated that an important part of an improved counseling system, using advances in computer-assisted counseling technology, would be the design of improved assignment methods that would benefit both officers and Army management.

Much has been written about the optimum use of material and personnel resources (Dwyer, 1954; Gass, 1958). For enlisted personnel, assignment systems that use aptitude area test scores within existing policy and practices are feasible and are superior to manual assignment systems (Hatch, 1972).

The objective of this research project was to apply past findings to an experimental computer-assisted counseling system that could assign a large group of officers more efficiently and equitably.

The specific purposes were

1. To quantify and objectify the assignment policies and practices of an illustrative career branch;

2. To determine if a computerized assignment system is both feasible and efficient; and

3. To evaluate computer-assisted assignments, both by comparing computer assignments with the actual assignments and by having experienced assignment officers rate the acceptability of the computer placements.

METHOD

Initial research on designing an experimental computer-enhanced system focused on Army first lieutenants, captains, and majors. In developing an experimental assignment module, the target population was limited to Infantry captains.

A sample of Infantry captains (N=160), comprising all members of an Infantry Officer Advanced Course for whom data were available, was used to evaluate the assignment module. The entire class had to be assigned before graduation and therefore provided a convenient sample.

Development of Job Utility Scores

Background data on individual officers were used to generate job utility scores. These scores expressed the judgments of experienced assignment officers regarding suitability of individuals for several job categories. During initial discussions with Infantry Branch assignment officers, sets of assignment categories and background variables were identified. These sets were used in making assignments. Each assignment category represented a type of job assigned to an officer based on career needs, qualifications, and preferences. The background variables formed the basis of determining an officer's career needs and qualifications.

After a general assignment category was chosen for an officer, a specific assignment was made on the basis of available requirements and the officer's geographical preferences. The assignment officers interviewed felt that their critical decisionmaking function was assigning an officer to the category that would most enhance the officer's career development while serving Army needs.

Infantry Branch personnel assign officers to nine categories:

1. Military education (ME)
2. Civil education (CE)
3. Overseas long tour (LT)
4. Overseas short tour (ST)
5. CONUS command (CC)
6. CONUS staff (CS)
7. Service school instructor (I)

8. ROTC instructor (ROTC)

9. Vulnerable to a reduction in force (RIF) (CONUS assignment).

The following seven background variables, considered collectively, were assignment category criteria:

1. Military education level (MEL)

2. Civilian education level (CEL)

3. Component (COMP)

4. Manner of performance (MOP)

5. Commissioned time in service (TIS)

6. Assignment history (AH)

7. Preference statement (PS).

After identification of the assignment categories and background variables, three assignment officers were asked to rate on an 11-point scale the importance of each variable for each assignment category on the scale, 0 = not important, 5 = somewhat important, and 10 = very important. The raters were instructed to assign to each variable the weight or importance it would be accorded in assigning an officer in relation to the officer's peers, given ample time for thorough review of all available records.

After further discussion with branch personnel, negative or positive values were assigned to all possible levels of each background variable for each assignment category. To express the policies and judgments of the personnel branch, an officer's coded background data were converted to coded values. These values ranged from +10 to -10, expressing the positive or negative values over which a background variable can vary independent of the variable's weight or importance in determining job category assignment. A utility score resulted from multiplying the appropriate job-specific weight by an officer's background datum (see Appendix A). These scores were then standardized and transformed to vary between values of 0 and 1,000, thereby permitting comparison among job categories (Macpherson et al., 1978).

The Assignment Program

The assignment program was designed to receive as input an N x K utility matrix (generated by combining the K utility scores of N officers) and to provide the following capabilities:

1. Officers can be assigned according to their highest utility scores.

2. Some members of the group can be assigned to their highest scores and the rest can be assigned optimally by a linear program.

3. The entire sample of officers can be assigned optimally.

Preliminary Adjustment of Weights and Values

The utility scores obtained from the ratings and interview statements of assignment officers had a high degree of face validity. The assignment officers who participated in the experimental exercise were part of the current system and represented the most knowledgeable source of information available regarding assignment of Infantry captains.

Nevertheless, feedback and discussion about simulated assignments resulting from use of utility scores enabled assignment personnel to refine and adjust their judgments, particularly when simulated and actual assignments differed.

A pilot, or preliminary, standardization group of 50 recently assigned Infantry captains provided an opportunity for branch personnel to adjust their judgments. Background data for this group were provided; then assignments based on utility scores were determined for group members and compared with actual assignments already given the officers. Discrepancies were discussed with branch personnel to determine if weights and values should be adjusted or if the actual assignment was non-optimal or atypical, e.g., a hardship case. The objective of re-evaluation was to improve the quality of the utility scores, not to match actual assignments. The agreement between the simulated and adjusted assignments was 75%, however, indicating considerable overlap in the algorithm and the real system.

Testing the Assignment Module

The following three methods were used to simulate the assignments of the 160 graduates of the Infantry Officers Advanced Course.

Assignment to Highest Score. Officers whose utility scores are highest in an assignment category are assigned to that category within limits imposed by job category quotas. This is an iterative method in which the quota of one job category at a time is filled from rank-ordered lists of officers with highest utility scores in that category. Residual quotas are computed for the unsatisfied job categories, and new sets of highest scores are computed for unassigned officers. The entire process is repeated until all officers are assigned and all quotas are satisfied.

Optimum Assignment. Optimum Assignment is a Ford-Fulkerson assignment algorithm (Ford and Fulkerson, 1957) in which the utility scores are assigned to job categories so that the corresponding average utility score for the entire group (the allocation average) is maximized.

Preselection. An officer is preselected for assignment to a job category if the difference between the officer's highest and second highest utility score is greater than a predetermined value. This value was 100 in the present study, in which utility scores could vary between 0 and 1,000 units. This method is used when a proportion of the total quota for a job category has been allotted for preselection. The rationale is to "skim off" officers who are singularly suited to certain job categories and to optimize the overall utilization of the rest of the group. In the present project, approximately half the quota for each job category was allotted for preselection.

The requirements or quotas for the various job categories are major factors in the assignment of a large group of officers. For the sample group of 160 officers, the following requirements were input to the program:

Military education (ME)	0
Civil education (CE)	36
Overseas long tour (LT)	26
Overseas short tour (ST)	8
CONUS command (CC)	63
CONUS staff (CS)	3
Vulnerable to a reduction in force (RIF)	15
Service school instructor (I)	9
ROTC instructor (ROTC)	0

The quota for ME was zero because the group was completing an ME assignment. No requirements for ROTC instructors occurred during this cycle because of the academic calendar.

The three computer-assisted assignment methods were evaluated by determining both the match with the actual assignments given independently to the group and the suitability of computer-assisted assignments that did not match actual assignments. The suitability of assignments is a more meaningful measure of the effectiveness of computer-assisted methods than is the match with actual assignments because more than one assignment may be suitable for an officer, and the actual assignment may not be the best choice. The suitability or acceptability of assignments was determined by having branch assignment personnel recommend suitable additional alternate assignments for officers whose computer placements did not match actual assignments. It was assumed that actual assignments had met certain suitability criteria. Therefore, computer-assisted assignments that matched either the actual or the suitable alternate branch personnel assignments were regarded as suitable matches.

RESULTS

Table 1 shows the percentages of agreement between actual assignments made by branch personnel and computer-assisted assignments. The percentages are presented as a measure of how well the assignment methods reflect branch policies and practices. The percentage match between actual assignments of advanced course graduates and results of the three methods using the assignment module provides a first approximation of the effectiveness of the computer-assisted method.

Table 1

Computer-Assisted Assignments Matched with Actual and Alternate Assignments of 160 Infantry Captains

Assignment method	% match with actual assignments	% match with alternate assignments	% match with either actual or alternate assignments
Assignment to Highest Score	58	24	82
Optimum Assignment	61	25	86
Preselection	58	22	80

The Optimum Assignment method had the highest percentage match with actual assignment, 61%. Both the Assignment to Highest Score method and the Preselection method obtained a 58% agreement with actual assignments.

The percentage of agreement between actual and simulated assignments is of limited usefulness because this measure does not consider suitability for other assignments based on career needs, qualifications, and available requirements. The match of computer-assisted methods with alternate assignments recommended by branch personnel provides a more realistic measure of a method's effectiveness.

The percentages of computer assignments that matched the alternate assignments recommended by branch personnel are shown in Table 1. The percentages for the methods of Assignment to Highest Score (24%), Optimum Assignment (25%), and Preselection (22%) indicate that many of the computer-assisted assignments that differed from actual assignments nevertheless satisfied branch criteria for successful placement.

The combined percentages of computer-assisted assignments that matched either the actual or branch personnel alternate assignments are shown in Table 1. The highest percentage of agreement with branch personnel assignments was achieved by the Optimum Assignment method (86%). The Assignment to Highest Score method (82%) and the Preselection method (86%) produced essentially the same percentage of matches.

The weights and values that generated the utility scores were provided by assignment officers under ideal conditions and after considerable discussion of pilot results. It was reasoned that the allocation average (the average of utility scores), if maximized, would represent the set of assignments most closely approaching the ideal. In Table 2, the allocation average of the group for the assignments by branch personnel are compared with allocation averages of assignment by the three computer-assisted methods. Table 3 shows that the allocation average for the actual assignments fell significantly below the scores for the three computer-assisted methods.

Table 2

Allocation Averages for Four Methods of Assignment

Assignment method	Allocation average
Actual Assignment	739
Assignment to Highest Score	801
Optimum Assignment	808
Preselection	799

The Preselection method assigned 48% of the sample to the job category for which they had the highest utility score. The version of the program used, however, was subject to chance order effects that allowed preselection to a job category of individuals who had overall utility scores lower than those of other qualified candidates. An improved version of the Preselection algorithm (Granda and McMullen, 1974) corrects this problem.

Table 3

Allocation Averages Compared

Comparisons of allocation averages	t-value	p*
Actual vs. Assignment Highest Score	6.34	<.005
Actual vs. Optimum	7.39	<.005
Actual vs. Preselection	5.99	<.005

*Based on a one-tailed test.

Discussion with branch personnel yielded three main reasons for the lack of agreement in cases not suitably assigned by the three computer methods:

1. Requisite data had not been posted on the officer's tape record,

2. The coded value in the record was not adequate for making policy discriminations, and

3. Officer preferences were weighted high enough to offset a disqualifying value.

The third source of disagreement is easily corrected because it involves merely "tuning" the weights and values in the assignment program. The first two causes of disagreement are more serious problems. They are a function of the input data, and the resulting malassignment therefore should not be regarded as a failure of the methodology of computer-assisted assignment. However, these causes of disagreement can be corrected by improving the system of online recordkeeping.

Computerized assignments not acceptable to branch personnel involved assignment of unqualified officers to Civilian Education (CE) and failure to assign volunteers to Overseas Short Tour (ST). Within an operational system, these malassignments would not be serious. All officers tentatively assigned to CE have their personnel file reviewed by a Civilian Education Assignment Officer, and a list of officers who volunteer for Overseas Short Tour is maintained by the Overseas Assignment Office. Both categories of assignment, therefore, would be reviewed independently before orders were issued.

CONCLUSIONS AND IMPLICATIONS

As demonstrated, the assignment module can assign Infantry captains in an optimal or near optimal way that satisfies criteria imposed by branch policies and practices. The high percentage of assignments acceptable to the assignment officers suggests that assignment algorithms now can provide a useful ancillary source of information without including additional background items. The percentage of acceptable assignments would be even higher in an operational system, in which codes would be tailored to system requirements. Special cases, such as family hardships or night school enrollment, which were not captured in the present assignment algorithm would be pulled and assigned "by hand."

If the assignment module were implemented, additional data would be included, and the fit of officers to job categories would be improved. Even in final form, however, the assignment module is seen as only one component in a computer-enhanced process. Final assignments generated by the system would be reviewed, and the final decision to approve or amend each assignment would be made by experienced branch personnel.

Some advantages a computer assignment system can offer are as follows:

1. Officers can be assigned to job categories with greater speed.
2. Assignment officers can consider a large number of officers and available positions simultaneously.
3. Assignment of officers who cannot contact their branch regularly can be made more equitably and with greater objectivity.
4. Branch personnel can devote more time to special cases.
5. Automated evaluation of predefined background variables can insure that relevant variables are not overlooked.
6. Computerized files can be handled more efficiently than can bulky personnel folders.

To best use the capabilities of a computerized system, all the background variables input to the assignment module should be readily accessible online from an officer master file. All file information must be up to date and accurate. The background items used in the present research are among the more important data items in an officer's record and should be high-priority items in any file maintenance system.

The assignment program could be exercised in advance of assignment deadlines to generate lists of two or three possible assignments for each officer, as shown in Figure 1. These assignments, based on an officer's utility scores, would be for jobs for which the officer was qualified and would be consistent with the officer's career needs.

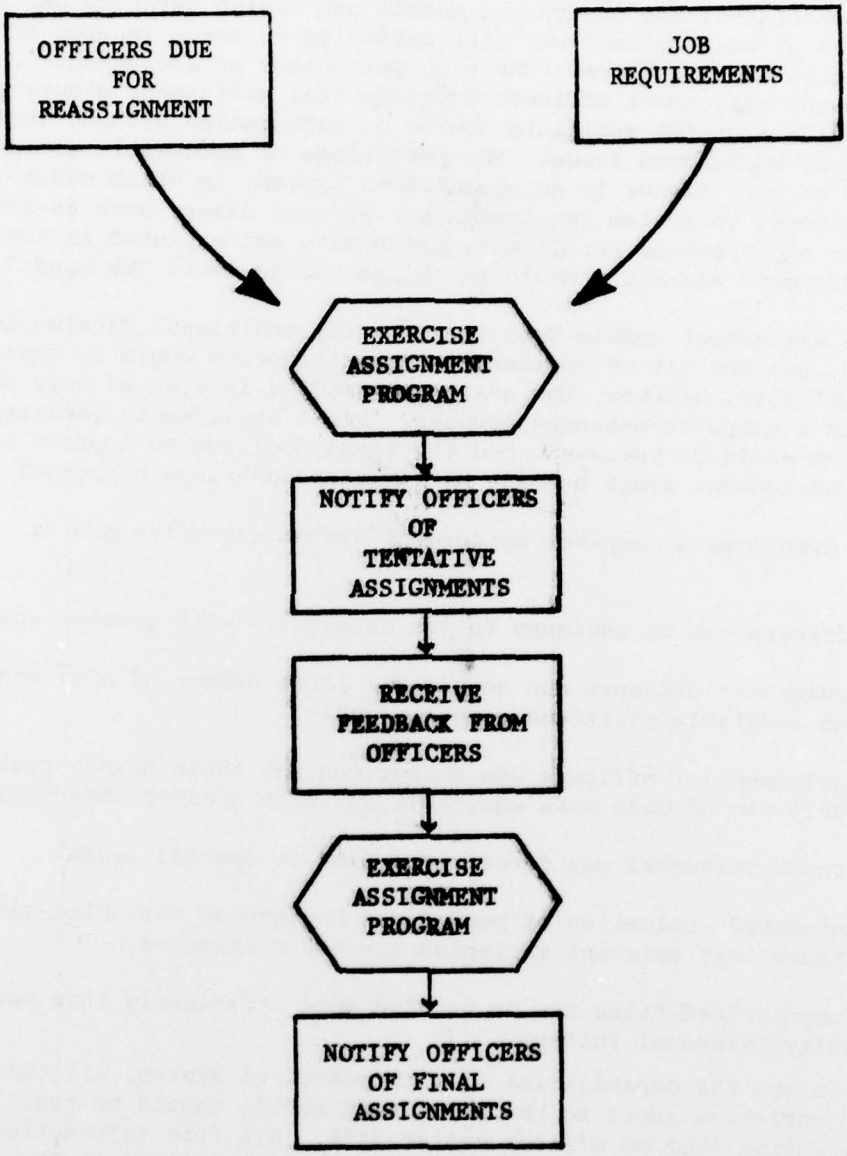

Figure 1. Possible utilization of the assignment module with officer feedback.

For the officers, a clear advantage of the assignment module is knowing that their preferences have a predetermined influence on the final assignment decision. The speed and efficiency of such a system also would permit feedback of an officer's individual preferences among possible assignments. Individual preferences would become a more meaningful part of the assignment process.

In summary, research to date indicates that assignment policies and practices of career branch personnel can be captured and implemented in an assignment module designed to be part of a computer-aided career counseling system. The results obtained with a sample of 160 Infantry officers suggest that a computer-aided system is a feasible approach in matching officers to jobs whenever a large number of assignments must be made simultaneously.

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APPENDIX A

CONSTRUCTING AN N x K MATRIX OF UTILITY SCORES

The data for each individual on j background variables is expressed as a vector of n one-digit scores. Each score has a corresponding value, which may be positive or negative, for each job category. The values corresponding to an individual's background scores are retrieved from a look-up table which is part of the data input to the program stored in memory. This results in a vector of n values for a specific job category.

An individual's utility score for a given job category is obtained by multiplying the (1 x j) vector V of values described above by a (j x 1) vector W of weights representing the importance of n background variable for that job category.

$$ {}_1V_j \times {}_jW_1 = {}_1u_1 $$

This results in a matrix whose single element is the individual's utility score for one of the K job categories.

If this process is repeated for each of the K job categories a vector can be constructed which contains the individual's utility scores for all job categories, i.e.:

$$ (u_1, u_2, \ldots, u_K) $$

By combining the vectors of utility scores for N individuals an N x K matrix S of utility scores results:

$$ S = \begin{bmatrix} u_{11}, u_{12}, \cdots u_{1K} \\ u_{21}, u_{22}, \cdots u_{2K} \\ \cdots \quad \cdots \quad \cdots \quad \cdots \\ u_{N1}, u_{N2}, \cdots u_{nK} \end{bmatrix} $$

This matrix contains the utility scores of N individuals for each of K job categories.

Before input to the assignment algorithms, the utility scores of the sample of individuals with each of the several job categories are standardized by adding the absolute value of the minimum score to each score, then dividing the adjusted score by the possible range of scores. The entire matrix of scores is then transformed to permit a possible range of utility scores between 0 and 1000.

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